Water Resources Decision Support Framework (WRDSF)

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Abstract

A software framework is presented for software modelling utilities used for decision support during the assessment of water resources. The Department of Water Affairs and Forestry have been developing the framework over the last four years. The framework is already available and two models are supported. This paper presents a summary of the goals of the framework:

- The framework should manage the instantiation of model interface servers so that models can be linked to each other.
- The framework should facilitate the sharing of information by supporting a common information archiving and restore mechanism.
- The framework should support the inclusion of generally useful utilities like GIS viewers and time series graphs.
- The framework should support a common model and study selection mechanism so that a user can navigate from study to study and model to model in a common way.

Keywords: *Water Resources Decision Support Framework*

1 Introduction

The South African Department of Water Affairs and Forestry (DWAF) have been developing a number of decision support systems to support the water resources planning process. A structured approach has been adopted for the design of these systems to maximise software re-use and to minimise development costs. A spin off from this structured approach has been the emergence of a framework for the systems. PD Naidoo & Associates (PDNA) has been involved in this effort from the beginning and plays a central role in the design of these systems and the framework.

A modelling framework is a software application that contains a number of scientific models. The framework contains multiple models to achieve two main objectives:

1. Models can be linked together. The output of one model can be used as the input to another.
2. Models can use common modelling utilities which saves time for the model developers.

The example shown in this diagram is for a typical system yield and planning analysis. A different type of analysis would involve different models within the same framework.

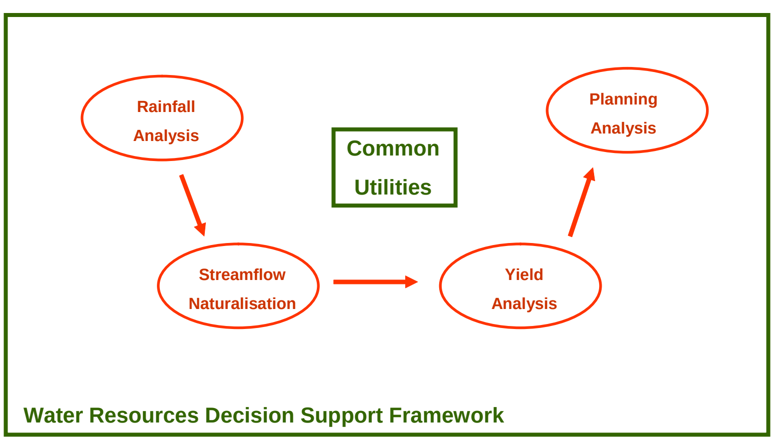

Figure 1. Conception schematic of the water resources decision support framework.

There are two to main objectives for developing an integrated modelling framework:

1. A framework can reduce costs. Lower costs are achieved by:
    a. The output of one model is linked to the input of another model. This eliminates the need to reformat and manipulate model output. Data file reformatting is a significant portion of the cost of most studies.
    b. By supporting a common data archiving mechanism the framework can significantly reduce the costs of obtaining previous studies.

2. A framework can increase the capabilities of an embedded model.
    a. Imbedded models can interact dynamically during the solving process. Models were previously run in isolation of each other. This dynamic inter model interaction can significantly increase the capabilities of a model's algorithm.
    b. Models can make use of common modelling utilities that already exist in the framework.

2 Background

A number of organizations around the world have been looking into the issue of integrated water resource modelling frameworks. The benefits of having such a framework are therefore widely understood. One of the common threads that weave through most initiatives is the principle that models need to be linked together. The linking of models is also a central theme for the WRDSF.

The main reason for linking models is to reduce the cost of performing water resource evaluation projects. It has been estimated that the cost of such a study could be almost halved if the inefficient data manipulation activities involved in feeding the output from one model into another model's input data could be eliminated.

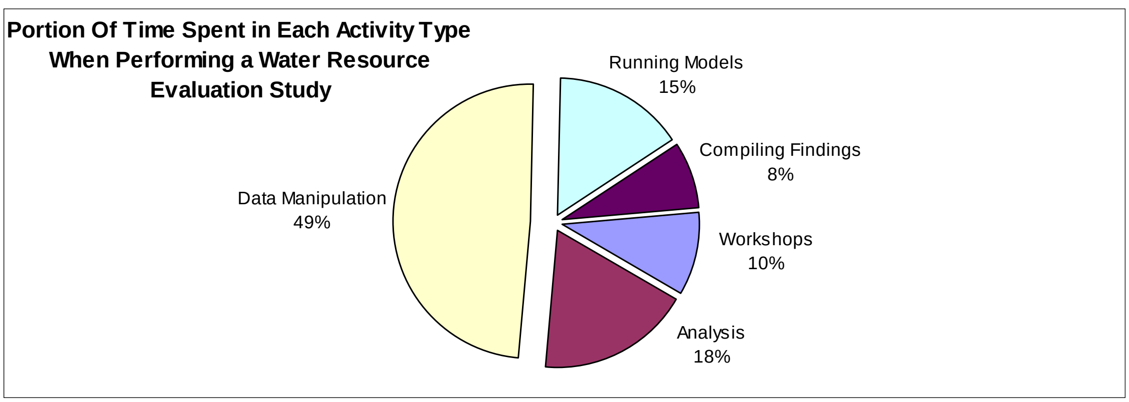

Figure 4. Portion of time spent in each activity when performing a water resource valuation study.

This chart shows the relative portion of time spent by individuals in performing a water resource evaluation study. The information was compiled by interviewing industry professionals working in this field in South Africa. The type of study represents a comprehensive system yield analysis. The scope of this study started with the collation of raw input data (including rainfall records) through to performing a yield and planning evaluation for the system.

3 Features Required for a Water Resource Decision Support Framework

In order for a framework to achieve the objectives of reducing costs and increasing capability there are a number of features that the framework needs to support. These features are described in this section.

3.1 Imbed Models

In IT technical terms the framework should manage the instantiation of model interface servers so that models can interact with each other. In non-IT terms this means that the framework is the main program and it creates an instance of each model in memory that is required to perform a task. This instantiation should eventually support the Microsoft DCOM mechanism for managing distributed objects and the more open mechanism of web service servers for distributed interaction.

- The output data from one model could be used as the input data to the next model.
- One model needs to be able to invoke functionality of another model.

3.2 Share Information

The framework needs to facilitate the sharing of information.

- It should be possible to export a study or import someone else's study.
- It should support a national archive of base data like previous studies and rain gauge historic data, etc. This mechanism should incorporate wide access to information via the internet (www.usersupport.co.za – a web site maintained by DWAF for users of water resource decision support systems).
- The import and export mechanism should be common to all models.
- It should support the inclusion of broader model meta information like study reports and reference material to make the sharing and re-use of model studies easier.

3.3 Generally Useful Utilities

The model framework should contain generic utilities that are generally useful in the field of water resource analysis. These should include at least:

- A GIS viewer.
- A time series comparator and time series graphing utilities.

3.4 Model Redistribution

- The framework should support the redistribution of models. The owner of the framework should administer the redistribution of models integrated into the framework in an efficient manner. The user should be able to download the software from the web or obtain a CD containing the framework and all the models that are licensed to that user. A simple installation program should run to install everything required.
- It should support multiple concurrent versions of each model. The reason for this is that models change on a regular basis as the model is extended and improved. Studies in a particular area however occur less frequently – every five or ten years. As a result it is unlikely that a new study in a particular area will be able to use the same model that was used in that area for the previous study because the model may have changed significantly.
    - It should be possible to run even very old studies with the version of the model that was used in the original study so that exactly the same results could be obtained now compared to what was obtained then.
    - There should be no specific need to upgrade the data structures of an old study to accommodate enhancements in subsequent versions of a model.
- It should support the licensing of individual models.
- It should support the redistribution of open models.
- It should support the redistribution of propriety models and include a copy protection mechanism.

3.5 User Access Control

The framework should incorporate suitable user access control.

- National base data like previous studies and rain gauge historic data should not be modifiable by a user.
- A consultancy should also be able to limit the access of a particular user by defining the role that that user has with respect to a particular study or with respect to a particular model.

3.6 Easy Model Incorporation

It should be simple to integrate a model into the framework. To this end a software developer's kit (SDK) for the framework needs to be available.

- The source-code for the framework should be available, well documented and include an example of an integrated model.
- Common utilities and components need to have a specification of the interface to the component to make it possible to use the component.

3.7 Cross Model Scenario Management

The framework should support a common scenario management mechanism so that scenarios can be established across models. A scenario is a set of alternative values for parameters of the model. This set is called a "change list" in this paper.

- This should include parameter change lists which can be applied optionally.
- It should also include meta-data on scenario change lists.
- It should include audit trails to keep track of changes made.

3.8 Common Study Selection Mechanism

The framework should support a common model and study selection mechanism so that a user can navigate from study to study and model to model in a similar manner.

3.9 Common Data Dictionary

The model should support a common data dictionary mechanism so that the various models publish their model parameters in a consistent manner to allow cross-model parameter management. This is important when it comes to linking models together. The output from a model should be in the form of published model parameters so that any other model can use these parameters.

4 Progress To Date

The WRDSF is currently available and this section presents the progress to date.

4.1 Systems Supported

Two systems are currently supported:

- Water Resources Yield Model (WRYM).
- Rainfall record patching system (RainIMS) which incorporates two earlier systems for rain gauge selection, CATCHR, and record patching, PATCHR, (DWAF, G Pegram, BKS).

4.2 Framework Functionality

The diagram below indicates how much of the overall functionality of the framework has been completed.

Five of the nine functional categories have been completed. Three are approximately halfway. Work has just begun on one of the categories.

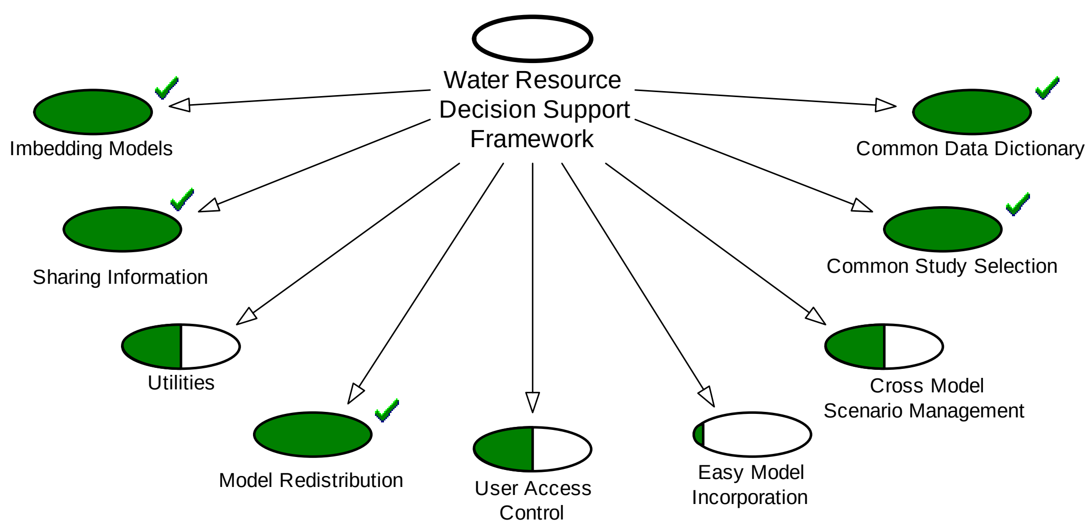

Figure 5. Portions of the WRDSF complete at the time of this paper.

5 Future Work

The future work identified for the water resources decision support systems are presented below:

- New systems for incorporation into the framework include:
    - Naturalised Flow Information Management System.
    - Stochastics Generation System.
    - Water Resources Planning Model (WRPM).
- Scenario management has been highlighted for improvement and extension.
    - Provision for cross model scenarios is required.
    - A more sophisticated mechanism for grouping parameter change lists is required.
- Once the framework has stabilized it is important to provide a software developers kit for the framework to reduce the cost and incorporating new models.

6 Conclusions

The Water Resources Decision Support Framework has provided a consistent and structured approach to facilitate the progressive development of individual decision support systems. By including multiple models, facilitating the sharing of information, providing generic utilities and allowing cross-model scenario management the framework will be of great benefit to support water resource planning studies undertaken by DWAF and others.

References

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